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ABSTRACT

This paper examines the preprint as a medium of information in the communication process among scientists. The proliferation of scientific research since World War II has increased the prevalence of preprints as a means of coping with the volume of science literature worldwide. This project collected data via a search of publications during the past 20 years, letters of inquiry sent to nine librarians, field trips to two preprint libraries, and interviews with selected individuals. Data on the historical foundations of communication in science, participants in the process, the use of the preprint, methods of access, and recommendations for future research are included. Findings indicate preprints are often the first source of recorded research accessed by scientists to keep up-to-date on current progress in any field. Information dissemination among scientists with common interests provides feedback for the perfection of the permanent record prior to formal publication. Proposed questions for further research are discussed. A list of personal correspondence and interviews, an extensive bibliography, and copies of related correspondence are included. (Author/THC)

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NORTHERN ILLINOIS UNIVERSITY
DEPARTMENT OF LIBRARY SCIENCE

THE ROLE OF THE PREPRINT IN COMMUNICATION AMONG SCIENTISTS

by

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ABSTRACT

The purpose of this paper is an examination of the preprint as a medium of information in the communication process among scientists. Findings indicate it is a first source of recorded research accessed by scientists to keep up-to-date on current progress in any field. Its dissemination among scientists with common interests provides feedback for the perfection of the permanent record prior to formal publication. The proliferation of scientific research since World War II has increased the prevalence of preprints as a means of coping with the volume of science literature worldwide. While this preliminary form of reporting became the object of debate during the 1960's, it presently appears to be accepted without question within the scientific community. However, research on the preprint in particular is a lacuna in the literature.

The collection of data utilized a search of publications during the past twenty years, letters of inquiry sent to nine librarians, field trips to two preprint libraries, and interviews. Data on the historical foundations of communication in science, participants in the process, the use of the preprint, methods of access, and recommendations for future research are included. Proposed questions need to be answered by more exhaustive investigations that address the issues of disseminating the prominent preprint in the age of computer technology.

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I. INTRODUCTION

From the initiation of research until the recording of its results within universal knowledge, the flow of information follows various forms and stages. A significant first step in the information flow from the laboratory to the library is the informal exchange among scientists.

Prepublication reporting tends to have some sequential organization.[1] Generally, it begins with an oral report within a scientist's own institution and continues with a presentation at a national meeting of a scientific society. The written record has yet to be perfected. It is at this plateau that the preprint (a copy of a manuscript being prepared for formal publication) is initialized. While the primary aim of the scientist is to perfect a communicative form of an authentic experiment, a pragmatic factor must be considered:

> "A central fact of a scientist's life is that if he or she is to get credit for research done, the results must appear in print and must appear before anyone else's results are published. The esteem of one's peers, the promotion at work, or the Nobel Prize all come to the man or woman who is first in print with the new theorem, theory or results."[2]

To lay claim to a research topic, time becomes a significant variable, and for this reason preliminary reports of research-in-progress are imperative in the practice of science; and the result is a host of subproducts of the whole that increases the volume of scientific literature. Among them are the preprints.

While the patterns of scientific communication have been a prominent subject of past research,[3] the preprint in particular has not been the central

focus except as an object of controversy and debate.[4]

Purpose

The purpose of the present research is to examine the preprint as a medium of information among scientists within the past twenty years. Questions to be answered are: (1) what are its historical foundations? (2) what is informal communication vis-a-vis formal communication? (3) what user needs does the preprint fulfill? (4) does the preprint facilitate the formal publication of scientific research? (5) what methods of access to preprints are available? (6) is the preprint prevalent in the communication process or has it been rejected? (7) will the preprint be one day a form of an electronic journal?

Methodology

While the use of preprints in particular areas of science depends upon different variables, no attempt is made to analyze every one. Rather, a general pattern of use within the broad spectrum of science is the objective.

The research design utilizes (1) an analysis of published literature, (2) field trips to two science libraries for observation and interviews, and (3) correspondence and telephone conversations with nine librarians in both science and academic libraries.

It is recognized that a nonrandom selection of libraries and the size of the sample will not result in conclusive scientific evidence. However, the assumption is that data gathered from reputable institutions will serve as indicators for future research and provide a focus for preliminary questions.

Answers to these questions will provide insight into the communal

activities of science that attempt to reduce the complexity of the discipline through the informal communication process.

Definitions

The term, preprint, has been ill-defined. The historical order of sense as recorded by the Oxford English Dictionary and Supplement is

> "Preprint . . . Something printed in advance; a portion of a work printed and issued before the publication of the whole.
> 1889 Academy I June 385/2 Dr. Charles Waldstein..has made arrangements with the American Journal of Archaeology..to issue these papers independently in a series of 'preprints'.
> 1903 Dial (Chicago) I Feb. 93/I A preprint from the Decennial Publications of the University of Chicago.. Other preprints in this series are as follows.[5]
> 1929 E. C. Bingham Some Defs. Rheology I This paper is issued in preprint form primarily to stimulate discussion."[6]

Webster's Ninth New Collegiate Dictionary defines "preprint" as

> "preprint n. (1889) 1: an issue of a technical paper often in preliminary form before its publication in a journal 2: something (as an advertisement) printed before the rest of the publication in which it is to appear."[7]

In the library world, the assigned definition in the ALA Glossary, published in 1983, is

> "preprint - a portion of a document containing one or more works which is printed and distributed prior to the publication date of the whole, such as an article from a book or periodical."[8]

The Encyclopedia of Science and Technology gives a definition of more specificity. The 1971 edition presents a sense of use in the context of science:

> "Preprints are research-in-progress reports to the small but often international group of fellow scientists working in the same relatively narrow research speciality, somewhat after the fashion of their 17th-century predecessors. Like government research reports, the preprint

> is a primitive form of technical literature, unrefereed and unannounced but historical."[9]

In the literature of science, several definitions are attributable. Grogan made a distinction between "so-called 'preprints'" and "real 'preprints'." The "so-called" are reports of recent work circulated within closed groups (invisible colleges) that may or may not appear "in print" at all:

> "They are often preliminary, conjectural, tenative reports, distributed as much for comment and criticism as for information . . . do not pass through the normal refereeing process, and by their nature cannot be subjected to any form of bibliographical control . . . they are collected, used, and sometimes cited (often in the form 'personal communications'.)"[10]

"Real preprints" are articles about to appear in regular journals:

> "The preprints are advance 'pulls' of individual articles taken before the regular printing run; e.g. Journal of Psychology prints and publishes articles as separates on receipt, and only later are they issued as part of the quarterly volume."[11]

Michael Moravcsik used the word "preprint" to denote

> ". . . any duplicated scientific communication, whether intended for publication in that form or not. Although this usage is somewhat misleading, I know of no other concise expression that would universally convey the same meaning."[12]

Simon Pasternack refuted the definition of Moravcsik as being appropriate for the term, "document." In its stead, he reserved "preprint"

> ". . . to denote a duplicated manuscript that has been or is about to be submitted for publication in a regular . . . journal."[13]

For the purpose of the present paper, the "preprint" is defined as

> a record of research distributed among scientists prior to formal publication.

No limitations of "complete" or "incomplete" are imposed. While the role of the preprint in the informal exchange among scientists is a primary

concern, the parameters of its domain have yet to be explored.

For the purpose of clarification, related terms to be used are defined in the following manner:

> Reprint. A copy of an article run off after the main printing in a formal publication. "It is usual for scientific journals to provide . . . reprints . . . . Authors use these for sending to their friends . . . specialists in their field, or to those who request them."[14]

> Anti-preprint. A term used by SLAC (Stanford Linear Accelerator Center) Library in their weekly pulication, Preprints in Particles and Fields, to denote preprints that have been published in formal literature.[15]

In a discipline as multifaceted as science, the term, "research scientist," could be defined endlessly. However, for the present, it will denote

> one actively participating in scientific-information production.

II. DOMAINS OF SCIENTIFIC COMMUNICATION

Communication among scientists is not a new phenomenon. It began as an exchange of information by scientists on a selective basis who met to share the results of their research. Such informal gatherings led to the formulation of the world's first scientific society in 1660. With the approval of King Charles II, John Wilkins, Robert Boyle, Sir Christopher Wren, and others organized the Royal Society of London.[16] A common custom of these 17th century scientists was communication through letters.

A concomitant of the informal exchange of information that began to formalize was communication through published literature. In 1665 the first scientific journal was founded by de Sallo, a counselor of the French court of the Parliament. The initial issue of the Journal des Scavans contained ten articles, letters, and notes.[17] By 1800 an estimated 90 scientific journals were being published worldwide, and the number increased to over 10,000 by 1900.[18] At the International Conference on Science Abstracting in 1949, estimations cited more than 40,000 scientific and technical journals that collectively published 1,850,000 articles yearly.[19] In the United States, by 1977, the body of scientific and technical knowledge grew to an estimated 15,000 books, 4,500 journals, 4,500 other periodicals, and thousands of technical reports. This accumulation represented current literature only that had been produced by 2.8 million living scientists.[20] The addition of past knowledge on an international scale would increase the volume to even more impressive dimensions.

As the surface structure of communication in science evolved and

multiplied, so, too, did its underground networks. From the early custom of sharing information through letters and informal meetings among scientists with common interests grew a form of organization in modern science known today as the "invisible college." The term, introduced by Derek Price in 1961,[21] was defined by him in the following manner:

> "The basic phenomenon seems to be that in each of the more actively pursued and highly competitive specialties in the sciences there seems to exist an 'ingroup'. The people in such a group claim to be reasonably in touch with everyone else who is contributing materially to research in the subject, not merely on a national scale, but usually including all other countries in which that speciality is strong. The body of people meet in select conferences (usually held in rather pleasant places); they commute between one center and another, and they circulate preprints and reprints to each other and they collaborate in research. Since they constitute a power group of everybody who is really somebody in a field, they might at the local and national level actually control personal prestige and the fate of new scientific ideas, and intentionally or unintentionally they may decide the general strategy of attack in an area."[22]

Since the time Price submitted his prototype definition to the content of science vernacular, it has been re-examined and refined by himself and many others--Crane, 1969, 1972; Parker et al., 1968; Griffith et al., 1971; Crawford, 1971; Gaston, 1972; Zaltman and Kohler, 1972; Mullins, 1973; Mulkay, 1975.[23] While the purpose of the present paper is not to examine the intricities of the "invisible college" as they exist among numerous specialities in science, these studies, among others, provide documentation that generally support Price's original perception. Science is a competitive discipline that divides its content categorically. Through interaction among core groups, the dispersion of knowledge takes place in a manner that enhances its utility. By selecting their own society, scientists determine where, when, and by what means information is to be presented. In the

words of Menzel, they have

> ". . . worked out a rich set of customs, habits, traditions, mechanisms, tricks, and devices as to how one goes about obtaining information, what one does by way of screening and listening for information, and what one need not listen or attend to."[24]

Out of the past the social structure of science grew and adapted to changing environments. It recognized the need for personalized activity that permitted autonomy to determine what is relevant to a particular area of research and the responsibility to submit its records to a universal audience. Thus, the domains of communication were clearly identified.

III. INFORMAL COMMUNICATION VIS-A-VIS FORMAL COMMUNICATION

The differences between the systems of communication in the two domains have been defined by Garvey and Griffith:

> "Formal channels carry information which is public and remains in 'permanent storage;' informal channels carry information to restricted audiences and its storage is relatively temporary."[25]

Three basic characteristics of public information are essential, according to Ziman. It is fragmentary, derivative, and edited:

> 1. ". . . a typical scientific paper has never pretended to be more than another little piece in a larger jigsaw--not significant in itself but as an element in a grander scheme . . . the vast store of human knowledge . . . ."
>
> 2. "Scientific papers are derivative, and very largely unoriginal, because they lean heavily on previous research. The evidence for this is . . . citations that must always be published with every new contribution."
>
> 3. "A scientific paper is not a candid autobiography, but a cunningly contrived piece of rhetoric . . . it must persuade the reader of the veracity of the observer . . . external censorship is the function of the anonymous referees. We must be able to rely on the basic accuracy and honesty of what we read in other people's papers, for we are always using their results in the construction of our own researches . . . ."[26]

Information which passes along informal communication channels is characterized by Cronin as current, redundant, relevant, and open-ended:

> 1. "Modern technology--the telephone, air mail, jet travel--has greatly speeded up these channels, which are now much faster than the official publication procedures."[27]
>
> 2. "Some information appears on more than one occasion as it gradually develops into a form in which it will make its public debut in journal literature."[28]

> 3. "Participants in an informal network can select information and target information at specified individuals or groups."[29]
>
> 4. "Members of invisible colleges can discuss work in progress, its flaws and possible future directions without fear of public rebuke or criticism."[30]

According to King and his associates, the flow of information between the two domains may follow any one, or several, of fourteen different paths. Variables are the use of the information and the form of its transfer. Communication may be direct: from scientist-author to scientist-user or from scientist-author to scientist-colleague. The form may be informal oral communications, conferences, unpublished technical reports, preprints, or reprints of published articles. (The King et al. study defines the preprint as "any copy of an article's manuscript, before or after acceptance by a journal, that is distributed prior to publication and distribution in a journal.")[31] Communication may be indirect, and the forms in the transfer are formally published journals and books. Manuscripts flow from authors to publishers; publishers distribute articles and books to scientists or libraries, which then store and fulfill scientists' requests for information. Whatever path is chosen, the principal participants are the scientist as author and user, publishers, libraries, abstracting and indexing services, and data bases.[32]

For the transfer of information, King et al. cite ten basic functions as essential: research and information generation, composition of results, recording, reproduction, distribution, acquisition and storage, organization and control, identification and location, physical access, and assimilation by the user.[33]

From the view of Voigt, the choice of path to information depends upon the scientist's needs which he identifies as a trichotomy:

> 1. Current--based on the need to know what colleagues have recently done or are doing in the scientist's field.

> 2. Everyday--based on the need for some specific piece of data essential to his work.
>
> 3. Exhaustive--based on the need to find and check as much relevant information on a given subject as can be found.[34]

Sources of information, listed by Voigt, for the current approach are these:

> 1. "Information on current developments received orally from conversation with colleagues and visitors--'. . . conversation seems to be the scientist's most important source of information on progress in his field.'
>
> 2. Meetings and symposia, especially corridor conversation.
>
> 3. Correspondence, said to be the most important in very narrow areas of research or where the number of workers is low.
>
> 4. Preprints or reprints distributed through mailing lists.
>
> 5. Reading current or recent journals regularly or systematically. 'A good deal of current reading is the result of recommendations of pertinent articles by colleagues.'
>
> 6. Reading abstract journals--less common than it used to be because of the increase in size of the abstract journals.
>
> 7. Using indexes, contents listings or abstract publications as guides.
>
> 8. Reading reviews to follow developments in the field.
>
> 9. Reading monographs."[35]

For the everyday approach, conversation is even more important. Choices of information sources are determined to a greater degree by what is easily available. The general pattern of locating information established by Voigt is: "go to one's personal library or the collection on one's desk, ask the associate close by, go to the associate's personal collection, go to someone else, check through personal card files, try the

departmental library."[36]

For the exhaustive approach, first sources, assigned by Voigt, are periodicals, journals or printed reports, and secondary sources, such as handbooks, treatises, and abstract services. Again, information from colleagues--correspondence, unpublished papers, reprints or preprints, conversation--continues to be useful.[37]

From the creation of an idea, a pattern of communication begins and diverges in many directions, and the participants and the forms of transfer are equally divergent. To be the creator, communicator, critic, and consumer of information, the scientist, suggest Mulkay and Gilbert, has developed two "interpretative repertoires;"[38] and each language serves a particular set of functions.

Since its inception three centuries ago, the journal has come to be the major medium for formal language that represents the "heart" of scientific achievement.[39] It is Ziman's contention that it is

> ". . . a mechanism for the systematic publication of fragments of scientific work [that] may well have been the key event in the history of modern science . . . for it achieves a corporate, collective power . . . ."[40]

Its rôle has been three in number:

> 1. the archival role,
>
> 2. the dissemination or communication role, and
>
> 3. the social role of conveying prestige and recognition.[41]

However, the heartbeat of science appears to depend upon the constant flow of its "lifeblood,"[42] informal language, which flows through the system of informal communication. It is, according to Cronin,

> ". . . a device created by scientists for scientists to serve a particular set of functions . . . [it] is like a bench chemist's notebook; it contains a record

> of events, measures and ideas in 'natural' form and allows them to be chewed over, reshaped and tested against professional opinion before seeking to have conferred on them formal publication status."[43]

While the medium of information varies, a prominent one is the subject of the present research and has been described by one author in the following manner:

> "Another mechanism for the dissemination of scientific knowledge in advance of formal publication is the distribution of 'preprints.' For the reader who is unfamiliar with this practice let me explain that a preprint is a clumsy, bulky, semi-legible document, being a duplicated version of a paper submitted for publication but not yet accepted and printed. It is a mechanised version of the decent and proper custom of writing to one's friends, colleagues and rivals about one's current work . . . ."[44]

The "proper custom" grew within the soil of 17th century society, but the preprint sprouted a new shoot on its stem during the 20th century. During the Second World War, the circulation of research reports, often secret, became a common practice among interested participants outside the channels of formal publication.[45] Following the War, the impetus for scientific research produced an unprecedented output of scientific information that increased the need for disseminating current and vital data;[46] and the preprint became a more prevalent medium in the process of communication.

IV. USE OF THE PREPRINT

To determine its present role, a review of the preprint's utility, as recorded in recent literature, is preeminent; and an appropriate beginning appears to be a further study by one who submitted the first definition for the realm of its residence--the informal "invisible college."

Price's study (1965) found that 90% of the memos exchanged among a selected group of 592 scientists were preprints. Copies of papers intended for publication were sent to the central office of the National Institute of Health; and "without no editorial intervention," each was photocopied and distributed to the membership. The process provided scientist-to-scientist contact within a couple weeks rather than the several months associated with formal publication.[47]

The preprint was a predominate source of information for another particular group. Strasser's study (1978) at the University of Pittsburgh found more physicists named preprints as a source of references in published papers than any other source.[48] While a citation analysis of 323 papers revealed "acknowledgement of discussions" with other scientists to be more numerous, one hundred twenty-five preprints were cited within 76 papers.[49]

> "The preprints were frequently sent by the author directly to the user either as a result of a request or because the user was on the author's mailing list of people interested in his research. Other preprints were available in a large, informal collection."[50]

Parker's physicists (1969) at Stanford named the preprint as the most important medium of written communication.[51] They found it equal to or better than journal articles for

> --general awareness of the current state of theoretical high energy physics,
>
> --finding out who is working in what area and on what problems, and
>
> --informing others of one's own research activities.[52]

Preprint distribution in various fields was demonstrated by Hagstrom's study (1966) of supplementary modes of publication used by scientists. His survey audience was 1,947 United States academic biologists, chemists, mathematicians, and physicists.[53]

His findings indicated biologists were "much less likely to distribute large numbers of preprints than workers in other fields,"[54] but it was a characteristic practice among physicists.[55] Mean percentages, based upon the 10 to 24 response category of preprints distributed were: 23% (N=215), experimental physicists; 13% (N=121), theoretical physicists; 13% (N=254), mathematicians; 12% (N=458), chemists; 5% (N=257), experimental biologists; and 4% (N=120), other biologists.[56] As the number of preprints distributed increased, the physicists' percentages continued to outnumber the distribution rates of the other fields. In the 25 to 49 response category, 20% of the theorists and 12% of the experimentalists participated, while only 6% of the mathematicians, 4% of all the biologists, and 1% of the chemists did so.[57]

To test these differences, Hagstrom disaggregated the fields into smaller scientific specialities, defined as sets "of scientists in a discipline who engage in research along similar lines."[58] He concluded that the rate of preprint distribution in specialities was positively related to

> --the frequency of collaboration with colleagues in the same discipline,
>
> --the low division of labor in collaborative research (high division results in workers in close proximity who need not disseminate),

> --a tendency to disproportionately cite recently published work, and
>
> --a low continuity in research.[59]

Comments relevant to his conclusions were

> --"as a speciality's size increases, informally distributed reports become less efficient as a means of disseminating information;"
>
> --"as the number of links with persons working on similar problems within a single discipline increases, preprint distribution increases also;"
>
> --"as interdisciplinary work increases, shared work in collaboration declines, and the low division of labor has a positive correlation with preprint distribution;"
>
> --"in specialities where the rate of discovery is high, work becomes obsolete more rapidly, and journal publication lags have more serious negative consequences for the conduct of research, preprint distribution is more important."[60]

Hagstrom suggested the unexpected low and high rates of preprint distribution in biology and physics, respectively, may be due to the "distinctive culture" and organization of research that are particular to each one.[61] Both the expected and observed rates of preprint distribution by chemists were highest for those specialties most affected by physics which support his findings that preprint distribution is characteristic in the field of physics.

The low rate of distribution among mathematicians was interpreted by Hagstrom as the "anomic" condition of mathematics which diminishes the need for preprints:

> "Because of intense specialization and rapid change in the boundaries of specialities, mathematical audiences are often small, and competent work in mathematics often goes unrecognized."[62]

Further testing of preprint distribution by individuals revealed parallel conclusions with those of specialties:

--"variance came from field differences;"

--"those who worked in formally organized research institutes, who collaborated, but who did not divide the work in collaboration, were more likely than others to distribute many preprints;"

--"highly cited scientists tended to distribute many preprints, as did those who had recently received the doctorate;"

--"those who requested preprints also tended to be young;"

--"those who perceived their specialties to be growing rapidly tended to distribute more preprints;" and

--"concern about anticipation in current work had the expected negative relationship with preprint distribution."[63]

That the use of the preprint varies from field to field was also observed by Griffith and Miller (1968). Their survey of informal communication patterns among psychologists in three specialties revealed those active in psychoacoustics did not develop a preprint exchange group for two primary reasons. Key researchers were in close contact with one another's work, and the raw data and conclusions were "sufficient to keep researchers informed of one another's work."[64]

Scientists working in neuropsychopharmacology sent preprints to people working on related problems, but no longer maintained the preprint exchange group that once existed. The authors contributed these findings to two factors: the low publication lags of journals in some medical areas and the low number of active researchers in these particular fields. Therefore, the danger of overlap among research efforts was diminished, and the need for rapid informal communication was also. In this case, formal channels of communication were adequate.[65]

In the area of social perception, little communication existed, which was interpreted as a result of the structure of the specialty. Griffith and

Miller's conclusion was that research in social perception tended to be an avocational interest of social psychologists whose major contributions to science were published in the literature of their primary interests. As in psychoacoustics, the small number of key researchers in close contact with one another was an influential factor.[66]

The extensive studies of scientific communication, conducted by Garvey and his associates (1966-71), found the distribution of preprints to be a "highly personal and selective activity" among their scientists and engineers. Three-fourths of their authors (N=3676),[67] preparing manuscripts for journal publication, sent preprints to "colleagues working in the same area as that of their work." While mailing lists were used, the predominate recipients were persons requesting manuscripts because prior informal contacts had alerted them to an author's work. Nearly one-half of the authors honored these requests.[68]

Six was the median number of preprints distributed, and a simple calculation for translation provides a total of 11,028 preprints circulated by this sample of scientists. One-sixth of the authors disseminated at least 25. The activity occurred at various times:

> --one-half distributed at least one preprint before the publication of their articles;
>
> --one-third, before the submission of manuscripts to journals;
>
> --one-fifth, after the submission and before notification of editorial action; and
>
> --one-sixth, after receiving such notification.

Most of the authors distributed preprints on more than one of these occasions.[69]

Evidence indicated their main goal was to receive feedback for the modification of their manuscripts. Recipients' comments caused two-thirds of the authors to modify their manuscripts stylistically and three-fifths to

reanalyze data and reinterpret findings to make substantive changes in content.[70]

In terms of stages of work, the preprint was most useful for authors during the initial and final stages. During the initial stage, preprints helped scientists to define the problem and to formulate a scientific or technical solution. During the final stage, informative feedback provided useful information that was an aid to placing collected data within the proper context of existing data, to interpret it more fully, and to integrate findings into the current state of knowledge in a particular area.[71]

Characteristics of authors who distributed preprints were

--"they worked in their areas of speciality longer,

--devoted more time to basic research,

--worked at academic institutions more often,

--conducted their work more expeditiously,

--made more prepublication reports of their work, and

--devoted more time to new work in the same area as that treated in their [sample] articles."[72]

Second and third samplings (generations) surveyed in this series of studies were scientists conducting work in the same area as the first author-scientists. For each generation (Generation A, named by article-authors; Generation B, named by Generation A), "personal interaction" was valuable. Face-to-face discussions were the source of prepublication information for 48% of Generation A and 23% of Generation B; preprints, the source for 23% of A and 15% of B; and correspondence with authors, the source for 16% of A and 7% of B. While findings showed Generation A interacted more personally with article-authors, in either case informal information proved useful.[73] More "formalized" sources (published articles) were used by 19% of Generation A and 26% of Gneration B, which support the conclusion that

published literature is most useful to scientists farther away from the research front who have not gained access to information through the pre-publication process.[74]

Garvey's et al. data revealed information in their author's articles was six months to one year behind the research front at the time of its publication,[75] and this obsolescence was a prominent factor in the increase of informal communication:

> "The experienced information-consumer . . . tried to discover every means of obtaining information about ongoing or recently completed work relevant to his own work, i.e., he did not wait to find this information in a journal or secondary source."[76]

The multiplicity of roles the scientist plays in the communication process were clarified in these studies. The "typical scientist" was found to be continuously involved in both producing and disseminating scientific information:[77]

> --a disseminator, when reporting recent scientific findings to other scientists;
>
> --a seeker, when soliciting comments and criticisms from colleagues;
>
> --a user, when assimilating feedback for the perfection of work; and
>
> --a producer, once again, when starting new work before the initial work is published.[78]

These findings are supportive of the results recorded by King and his associates.

Garvey et al. conclude that the interaction of the production and the use of scientific information is "an essential feature of science." One is used to accomplish the other. In the vernacular of modern technology, input makes possible output that is necessary for the cycle to continue ad infinitum. Both languages of the two domains of scientific communication are

indispensable.

As the continuity of research was relevant in the findings of Hagstrom, it was also in the previously cited studies. While two-thirds of the scientists continued work in the same subject-matter of their articles, one-third moved into new areas. Interpretations of the data were that the discontinuity of individual research is significant and "an essential attribute of the collective progress of science."[79] Discontinuity appeared to generate time-consuming communication problems which suggested that "systems of selective dissemination of information must be remarkably flexible to be genuinely effective in satisfying ongoing information needs".[80] Such results provide further insight into the phenomena, "invisible colleges", and the preprint as a means of conveying messages among them.

Further proof is the results of Voigt's research which established a definite relationship between the methods and resources used to obtain information and the purposes for which information is sought. His conclusion was:

> "Throughout this study the importance of information obtained from colleagues, both local and distant, has been reported . . . one of the important conclusions of this study is the confirmation that information received orally and that received from print cannot be put into two separate compartments. Almost always the two work together. The scientist working in isolation from others in the same field is at a distinct disadvantage in not being able to obtain information directly from colleagues. In addition, he is not able to locate printed information as efficiently without the help and guidance of colleagues. It seems clear that if national or international information centers are to be established and are to be of much value, they should include scientists who are currently doing research in the field. The procedure would appear to be the only feasible way of providing the necessary link between scientist and literature--other scientists."[81]

In the meantime, scientists appear to be providing this necessary linkage through the preprint in abundance. On a national scale, in the United States in 1977, 2 million preprints of articles being prepared for publication

were transmitted from scientist-authors to scientist-users and colleagues via mail. Another 84 thousand were exchanged personally among colleagues who were co-workers.[82] While the cost of preprint distribution, cited by King et al. includes reprint exchange also, the 572 million dollar figure represents 13% of all journal communication expenditures, which, according to the researchers is "a significant percentage for an article form which is often considered to be secondary and informal."[83]

The data and conclusions from the studies cited appear to support those of Edwin Parker who wrote in 1969:

> "Knowledge of the extent to which scientists use interpersonal communication and prepublication materials may shatter preconceptions about dependence upon formal media."[84]

V. FORMALIZING THE INFORMAL

As the volume of scientific knowledge continued to multiply, the traditional preprint became the object of controversy and debate. While its utility to scientists as a personal communication appeared acceptable, proposals to assist its dissemination were not; and the result in the 1960's was the "perplexing preprint paradox."[85]

Early efforts in the United States of the National Institutes of Health and the American Institute of Physics to organize preprint exchange polarized the scientific community internationally. Critics characterized the preprint to be circulated in a more formalized manner as a "published," unedited, unrefereed, and unsolicited piece of bad literature that threatened the existence of the centuries-old journal and the integrity of science itself. To "print" and "pass" these preliminary papers in a more public manner would constitute publishing, in their view, and the journals would become mere archival depositories.[86]

Proponents countered the criticisms with the contention that preprints distributed through organized exchange would not differ in status from "preprints presently distributed."[87] As the preprint was never intended to be a substitute for a permanent record of research, it would retain its original role--a fast communication to invite comments and criticisms for the completion of ongoing work and to prevent pursuits that had already received priority.[88]

To answer the critics' concern over the confusion caused by the citations of "unpublished" literature "published" later, proponents argued more formal

control could facilitate the identification of earlier references for accuracy in the permanent record. Moreover, the quality of science would not disintegrate, but be enhanced; for "fast communication" helps to eliminate, more rapidly, "wrong results" and "unfruitful ideas" from the mainstream.[89]

The critics viewed the system of referees in journal publication as the motivating force that preserved the quality of science:

> "An idea, an experimental result . . . is not scientific knowledge just because I . . . have said it. It only acquires that status when it has passed through the critical filters of other minds and has become something that we, as a community of scholars, have accepted."[90]

Rebuttals indicated the authoritative referees may not be that reliable. While a chosen critic might be a better expert than the author of the article criticized, personal research takes priority; and time-limitations prevent being as up-to-date on the subject reviewed as the author who has concentrated on it particularly.[91] Other named negative effects of the refereeing process cited were

> --"[it] frequently filters out precisely the information that should be communicated and . . . direct communication with the author then becomes necessary;"
>
> --"frequently [it] eliminates interesting new ideas since the job of a referee is to see that a manuscript measures up to some standard . . . necessarily based on that which is old and established and therefore not new."[92]

Other scientists, besides selected referees, may be equally qualified to judge manuscripts' contents; and preprint exchange, in whatever manner, provides them the opportunity to do so.

Another issue was the cost of organized preprint distribution versus the existing systems. The critics claimed dissemination to a larger audience would negate the reduction of expenditures expected through centralized maintenance of a composite mailing list, duplicating facilities, and batch

mailing.[93] Proponents submitted reliable figures could be determined only by experimentation. At least one journal declared the proposed expenditures should be used to explore more efficient, effective, and rapid methods for "orthodox channels of communication."[94]

Amid the debate, editors of biomedical journals made the decision to reject papers circulated by the Information Exchange Groups of the National Institutes of Health. The journals accused the groups of perpetrating "an offence against scholarship," and, in retaliation, editors were charged with

> "an unwillingness . . . to face up to the obvious facts that the journals can satisfy only a diminishing part of the needs of the scientific disciplines in respect to communication of information."[95]

Although the IEG groups were terminated in February, 1967,[96] and the PIE (Physics Information Exchange) proposal never reached fruition,[97] the public dialogue focused attention on the problems of the growth of scientific literature. With the development of improved methods of duplication and the growth of computer technology, capable of controllable information storage and retrieval, old issues gained new meanings; and the whole process--production, evaluation, improvement, collection, classification, storage, distribution, and use of documents--was readdressed.[98]

The preprint, specifically, became headline news; and, depending upon the viewpoint of the observer, it was either a part of the cure or an epidemic of another disease. While proponents saw it as a means of dealing with the pressures of the post-World War II Era to publish-or-perish in the competitive world of science, the opponents observed increased preprint dissemination as the "beginning of the breakdown of the basic science communication system."[99] That changes were occurring may be demonstrated by D. J. de Solla Price's comment:

> "I think it means that the old-style function of the scientific paper is a dead duck."[100]

Semantics was central to the dissention. The preprint was variously defined (See Definitions), and the term, publication, also. All participants in the flow of information became involved--editors, publishers, librarians, scientist-authors, and scientist-users; and the issue of communication was subjected to a plethora of language that may have clouded the very process it intended to clarify. While past research indicates the preprint and the journal article grew concomitantly as mediums of information, attempts to formalize the informal met with rejection both previously and more presently:

> ". . . the scientific community is, and always has been, strongly opposed to the idea of a central preprint depository (further evidence for this was provided by the Royal Society report on scientific information systems in the UK [1981]) and still places great store in the peer review system, as a means of maintaining standards and of distributing reward and recognition."[101]

VI. PREPRINTS PRESENTLY

To answer the question--"Where are the preprints presently?"--informal communication through conversation and correspondence with a small sampling of librarians was conducted. Selection of libraries was based solely upon the opinion of this writer. The assumption was that the professionals working within these reputable institutions were likely candidates to respond to an inquiry on the role of the preprint as a medium of science information. The response rate was 100%, and the results were both expected and unexpected. While findings are not conclusive evidence, they do serve as indicators for further investigation that should be given serious consideration. Most importantly, the data supplied by practicing librarians was the determinant in the accomplishment of the primary purpose of this paper--to refocus attention on the preprint as a highly visible, vital, and viable medium for information exchange among scientists within the so-called "invisible" informal networks.

Scott Lee, librarian of the Research Institutes Library at the University of Chicago, stated:

> "The preprint's acceptance by scientists as a significant medium of information exchange is unquestioned. It is one of the first ways, outside of personal communications, to learn of progress on research problems."[102]

While the John Crerar Library is now the major science library at the University, which houses the collections in technology and the biomedical and physical sciences, a few small research collections in the physical sciences are maintained in other locations; and the Research Institutes Library is one of these. Here preprints are received from the Institutes and assigned an accession number as a means of retrieval. Each first author of a preprint

is given a catalog entry, and cross references from additional authors to the first are entered in the catalog also. Current preprints are displayed for one week and then located by accession number on open shelving to be checked out by users. They are retained for one year and then discarded.

Jane L. McKeever, administrative assistant for Science Libraries, wrote:

> "The retention policy is based upon research which shows that if the article is to be published, it will be during this one year period."[103]

Approximately 300 preprints are received each month, and 3,000 to 4,000 are in the collection at any one time.[104]

The Yerkes Observatory Library (University of Chicago), Williams Bay, Wisconsin, also receives preprints on a regular basis from institutions all over the world. A monthly listing is circulated to the campus departmental office and other laboratories. Preprints are displayed and retained until storage space is filled; then the oldest are discarded. Judy Lola, librarian, reported the Astronomy and Astrophysics Department no longer has its own numbered series of preprints, but preprints are exchanged on an informal basis with a particular faculty member's own colleagues. An interesting disclosure was the listing of preprints on the "yellow pages" of the Astrophysical Journal. One issue listed 59 preprints received by the North American Astronomical Publications during the period June 25 through July 13, 1984. Anyone who reads the journal may request a preprint.[105]

Carmela Carbone, head of the Reference Department of the Engineering Societies Library, New York City, stated:

> "In the engineering field, preprints are a very important source of information."[106]

The library collects and organizes preprints of supporting societies as well as those of many other societies whose topics are of interest to engineers. Preprints are sent automatically by the American Society of Civil Engineers,

American Institute of Mining, Metallurgical and Petroleum Engineers, American Society of Mechanical Engineers, Institute of Electrical and Electronics Engineers, and the American Institute of Chemical Engineers. Those of other societies are requested either on a standing basis or as a result of perusal of lists of forthcoming meetings.[107]

Many of the preprints are indexed in Engineering Index or in Ei Meetings. In the library, if preprints are not published elsewhere, they are bound and arranged numerically. Indexes are maintained, indicating whether or not they are published in more formal society publications. Preprints and/or the society publications in which they appear become a part of the library's permanent collection. Conversation with the librarian revealed the preprints vary in kind--those of meeting papers, symposiums, and manuscripts of journal articles as well.[108]

Previous studies have indicated the preprint is more useful within some scientific communities than others. Price Gilbert Memorial Library, Georgia Institute of Technology, Atlanta, corroborates these findings. According to Helen R. Citron, Associate Director of Libraries, their only preprints are those of meeting papers on microfiche sets sent regularly to the library. Others are not maintained because their "user population has not requested them."[109]

A very different reason for the absence of preprints in the Linda Hall Library (Science and Technology), Kansas City, Missouri, was submitted by Larry X. Besant, Director. He stated:

> "Linda Hall does not collect and organize preprints (or reprints either) . . . because they are not part of the formal, indexed primary literature."[110]

In Founders Library, Northern Illinois University, DeKalb, preprints are unavailable also. Nestor Osorio, science librarian, indicated an

academic library, such as Northern's, would have difficulty obtaining preprints. Even if they were readily available, the effort and cost of collecting them would not be compatible with frequency of use among the student clientele at Northern. While they may be useful to a few, other priorities must take precedence with limited monies budgeted.[111]

As the progression of the literature search made evident, the preprint is a medium of communication characteristic of physicists and of the particle physics community particularly.[112] The composite findings of correspondence, field trips, and interviews revealed a system of preprint exchange that works.

While the controversy of the 1960's produced dialogue on the "preprint perplex," solutions to the problem never materialized. At least none appear in the literature. However, the present research found that within a particular environment action was taken to develop and implement an experimental project. It was a co-operative effort.

Three Stanford Linear Accelerator Center (SLAC) librarians and the directors of the Center and the libraries took the initiative. The baseline for the planning was the experience of the participants who had founded the SLAC Library in 1962 "on a stack of dusty preprints and some coaching from a CERN (Conseil européen pur la recherche nucléaire) librarian." From its beginning, the library collected preprints and published a weekly list circulated to SLAC physicists. This current-awareness service allowed physicists to select and access information that was of primary interest. The success of the practice was evident as years passed when SLAC alumni continued to request copies of the weekly listing be sent to them at their new institutions. With a "reliable master key," scientists or librarians could acquire preprints quickly from authors.[113]

With experience as the point of departure, Louise Addis, Bob Gex, and Rita Taylor, librarians, and K. H. Panofsky and Art Rosenfeld, directors, developed a system for preprint communication for the whole particle physics community. Seed money for the proposal was obtained from the Atomic Energy Commission (AEC) which agreed to finance the printing and mailing of preprint lists to a larger audience for an 18 month trial period.[114] The primary objective was stated by Louise Addis:

> "Since the point of preprints is speed, the whole project was designed to promote it."[115]

Repro-ready copy to mailbox was accomplished within twenty-four hours. Elaborate subject classifications and indexes were rejected. To deal with the problem of identifying the transformation of the "preliminary" preprint into a "primary," definitive record, an additional listing, named Anti-Prints, was included--a practice of SLAC librarians for years. It identified the published preprint with journal, volume, and page references. The rationale was:

> "A lightning-fast preprint announcement list coupled with anti-print information would complement rather than compete with other physics publications and would not upset the delicate ecology of preprints by slowing them down or overstimulating the distribution of junk. The idea was consistent with a philosophy of preprints as ephemeral documents, rough but speedy."[116]

Computerization was developed by Edwin Parker and his SPIRES (Stanford Physics Information Retrieval System) group, financed by the National Science Foundation; and in January, 1969, the first weekly issue of Preprints in Particles and Fields, including the section Anti-Prints, was mailed. By April of that same year, the response to this more centralized service proved its utility. More than a thousand subscribers responded to an inquiry and indicated they wanted to continue to receive PPF. During 1970 the project became self-supporting and continues to serve the physics community world-wide today.[117]

Since the inception of the project, the growth of preprint exchange is evident in the figures compiled by SLAC librarians. In 1970, 3500 preprints were received by the library; in 1984, 6102.[118] Out of the 4093 preprints received in 1974, 58% had become Anti-Prints by October, 1976.[119] Estimates of those published in 1984 have risen to 70 to 80%.[120] The on-line data base, HEP (High Energy Physics), recently contains 110,000 records. They are all SLAC library preprints and report holdings since 1974, plus all journal articles and other documents contained in the DESY High Energy Physics Index produced by a sister laboratory in Hamburg, Germany.[121]

First-hand observation of the systems and services provided by two other sister laboratories' preprint libraries provided proof that the SLAC program works. Both Fermilab (Batavia, Illinois) and Argonne National Laboratories (Argonne, Illinois) utilize SLAC's services. Their organization of preprints is nearly identical to that at the University of Chicago, the administrative body of Argonne. The primary difference is the retention span of preprints received. At Fermilab it is four years; and at Argonne, two.[122] Their audiences are also high energy physicists; exclusively, at Fermilab; and in part, at Argonne.

Prior to this writer's September, 1984, field trip, Argonne had received the following number of preprints:

810 - January	489 - May
548 - February	632 - June
594 - March	580 - July
745 - April	763 - August

In addition to the print versions received, theoretical physicists at Argonne regularly search the HEP data base to locate others, according to Jean Castle, librarian. In both libraries the selection process is the responsibility of the physicists; and organization and control, that of the librarians. Reproduction facilities for all preprint information are also available.

To describe either library, only one adjective is necessary--active! Details of the action within a preprint library may be best summed up in the words of Bill Kirk, SLAC librarian, who categorized the modes physicists use to learn of new results or ideas in their field. The first three he calls Me, Them, and Him; and the last two, TGIF and Frantic, which may be renamed, the "Preprint mode" and the "Publication mode," respectively. His descriptions are the following:

> "TGIF. The one-up or old-dependable mode is effected by arriving at the SLAC Library each Friday just in time to be the first to glom onto the cream of the new Preprints as they go on out on weekly display.
>
> "Frantic. The last-resort or flipped-out mode arises only on such desperate occasions as the following. You have just hobbled into Vegas on a pair of improvised yucca crutches after 5 months at the bottom of the Fat Chance Silver Mine's long-abandoned and unlit shaft, and now you plunge into the first Smoke Shop on Neon Row and comb wild-eyed through the magazines for the plain green wrapper of a Physical Review Letters hidden away among all those plain brown wrappers."[123]

From the viewpoint of the scientist, who must keep up-to-date on the progress within the discipline, this may be the most accurate documentation to explain the need for preprints and the second form of the written word, formal publications. The interviews with Jean Castle and Roger Thompson at the Illinois laboratories' libraries verify Bill Kirk's vivid narrative. While journals are accessed and read, it was their consensus that physicists would not be able to conduct their work on a daily basis without the constant flow of information provided by preprints.

In regard to preprint libraries, another observation seems appropriate. When the PIE (Physics Information Exchange) proposal was submitted to the scientific community during the 1960's, the aim was to establish 300 preprint libraries throughout the nation, and the idea was met with a barrage of criticism.

One author wrote:

> "To expect high-energy theoretical physicists to go to their library to scan this flood (100 preprints monthly x factors ranging from 2 to 10) regularly and systematically, even for 'current awareness,' seems to me highly unrealistic."[124]

Although numerous variables have entered into the picture since the time this statement was written, the critics appear to have over-stated their opposition or, perhaps, failed to perceive the behavioral patterns of members of their own community.

One of the most unexpected results of this present investigation was the information received from the Smithsonian Institution Libraries. Since its International Exchange Service is the official United States agency for the worldwide exchange of scientific and scholarly publications and its Smithsonian Science Information Exchange, Inc. receives, organizes, and disseminates information about contemporary research in the life sciences, physical sciences, and social sciences,[125] it was expected that preprints would have, by the 1980's, received a maximum amount of attention. Apparently, this is not the case. A direct inquiry to the Washington, D.C., headquarters was sent for response to the librarian at the Astrophysical Observatory in Cambridge, Massachusetts, who wrote that she is the only librarian working for the Smithsonian Libraries who has "ever raised the point" of handling preprints within the organization. Her guidance was "do with them as [you] think best." Therefore, what is done has been the result of the ingenuity of one librarian.[126]

At the Astrophysical Observatory Library, a system of recording a shortened version of preprint titles, author, source, and reference number is recorded on a word-processor; and interested scientists can access the file on their immediate terminals. A series of preprints is also published; and through the distribution of printed lists, any interested parties may make their

own selection.[127]

In the opinion of the librarian, preprints are "a vital resource in libraries involved in state-of-the-art science, particularly in physics, astrophysics, and the space sciences in general."[128] Again, as among other librarians' experiences, the disappearance of preprints from display shelves is a good indication of their value to scientists.

The prescience of Joyce Rey, librarian, has verified an implication that has been present throughout the present project of research--the need to establish the vital importance of preprints, specifically, within certain fields and to develop more models that prove valid for their "handling."[129] The need for future and more exhaustive research on the preprint appears eminent.

VII. CONCLUSION

Communication in science is essential, for the solidarity of the discipline depends upon the sum of its parts; and, therefore, access to accurate information is necessary; or the work in the laboratory may be a fruitless exercise. While replication in science is requisite; duplication is not; and the very terms "discovery" and "invention" are defined by the what and how and who of previous and present endeavors. The path to "new" knowledge must begin with precedence as its basic premise before the method of science--hypothesis, experiment, results, and conclusions--can be utilized for progress.

The scientist involved in research is only one participant in a cyclic process that depends upon numerous, shifting variables within each area of a multifaceted discipline. The practice of science today is not an isolated venture. As Gaston points out in his book, The Sociology of Science, the days of Einstein and Fermi are over; and science is now, without question, corporate and competitive. While the humanist may set her/his own time clock for the completion of an artistic creation, the scientist is faced with a pragmatic determinate--lay claim to the territory first or move on to another piece of "property." Further, the notebooks of the "closet scholar" are a personal, private possession, but those of the scientist are destined to become a part of public knowledge. The ethics of science predicates a commitment to the submission of conclusive evidence to the consensus of a universal audience who, then, rightly possess the product of a mind whose germination was individual.

Thus, the communication patterns in science evolved to accommodate the

structure and ethics of the discipline, and scientists themselves have developed the mediums of information that best suit their needs to pursue the practice of their chosen profession.

Historically, the preprint is one of the scientist's own inventions that serves as a "notebook" in the preparation of conclusions that are winding their way to the press. Whether they are published or not is a moot question; but, nevertheless, it is the scientist's primary intention. Therefore, the variety of definitions (See Definitions) subscribed to the preprint appear to be useful only for semantic arguments; and the one designated for this paper seems best to eliminate the peripheral limitations that would restrict an exploratory examination of its role in the communication process. To define the preprint as "a record of research distributed among scientists prior to formal publication" allows the inclusion of general observations within the whole spectrum of science that a narrower term would not permit. In fact, "pre", as a prefix, appears to be the key stem in coordinating any information about its content and context.

Whatever else the preprint is, it is a preliminary form for the language of the scientist's informal repertoire. It is necessary before the second language can be expressed in the form that is permanent and, most frequently, the journal article--another invention of the scientist.

The utility of the preprint depends upon the context of the circumstances in which science is practiced. If it is one with narrow parameters with a minimum of participants, then the preprint is less essential. Immediate contact through conversation or the reading of journal articles may be sufficient, particularly in an information-rich environment close to the research front where the time-lag associated with published literature diminishes as a significant factor.

If the scientist is involved within an area of research that is highly competitive and depends upon the very latest data for progress, then the preprint becomes increasingly important. In addition, if the same scientist is situated in a remote location and has just begun a career within the discipline, contacts through the preprint are more essential.

Prestige is always a significant factor in the number of preprints any scientist distributes. After credentials are established through contributions that are cited, recognition that results in promotions, and acceptance that depends upon peer-review, then the scientist becomes a prime source of information for other scientists.

While it is outside the scope of the present research to identify and compare all the variables that determine the use of the preprint in all areas of science, the data collected appear sufficient to conclude that the role of the preprint in the informal information exchange among scientists is a major one. It may well be the most vital link that the scientist has on a worldwide basis to keep up-to-date on current progress in any field. At the present time it appears to be accepted without question.

VIII. FUTURE RESEARCH

Research on communication in science has not been neglected, but the preprint in particular has rarely been the central focus. While the present research makes no pretense of being exhaustive, it seems little has been written about the preprint during the 1980's. For a medium of information that is so prevalent, more attention appears eminent.

Even though the distribution of preprints tends to be a personalized activity, during the past twenty years the need for other participants has become necessary. As the King et al. study demonstrates, the flow of information is a complicated process that depends upon the participation of more parties than just the scientist. It involves the scientist-author, scientist-user, publishers, libraries, abstracting and indexing services, and data bases. The focus of the study was the journal system; and the survey conducted provided data on all participants, the forms of transfer, and the use of information. For future research on the preprint, projected figures for 1985 are relevant. The authors comment:

> "The multidisciplinary nature of current science and technology has led to the requirements for new sources of information beyond one's own journals."[130]

While the content of the present paper shows that the preprint is <u>not</u> a new source of information, the authors apparently consider it one of those "beyond;" and in spite of this point of contention, the figures that follow are useful. In 1975, the number of author preprints and reprints read by [illegible]eyed scientists as a source of information was 30 million. The authors [illegible]ne study project the figure will rise to 36 million in 1985, an increase

of 20%.[131] The cost per use in 1975 was $15.90; the projection for 1985, $30.20, an increase of 90%.[132] The total cost in reproducing and transmitting these author preprints/reprints in 1975 was 478 million dollars, and the projected figure for 1985 is 1,074 million, an increase of 125%.[133] To determine if these projections become a reality, a new study should be undertaken; and if they are, then, perhaps, improved means of disseminating preprints as a significant portion of that cost would be advantageous.

Further projections submitted were those dealing with the possibilities available in an age of computer technology. The line between informal and formal communication and publication will begin to blur more and more, and the roles of participants in the process of science communication will change considerably. Through electronic processes, it will be possible to write, review, edit, classify, retrieve, and transmit information.[134] One of the "substantial" advantages of such a system, according to King et al., is "the opportunity for an author to pre-select a specific target audience."[135] Since this is the precise reason the "invisible college" came into being historically and its primary form of information, the preprint, will its future form be that of an "electronic publication?"

While all of this is within the realm of possibility, one question must first be answered by future research, suggest King et al. and the present writer:

> ". . . is scientific communication such a complex economic and sociological phenomenon that progress will be hindered by tradition, as in any other social system involving complex interactions among numerous participants? We are optimistic. Already our children's electronic toys are more sophisticated than the transistor radios of only 20 years ago, and our children are the scientists of tomorrow."[136]

Although the technology is here, what will be the motivational factor?

While the scope of the present paper is too narrow to deal with the subject adequately, future researchers are referred to 1980's articles that record some of the studies in progress to test and develop systems for the transmission of scientific information through new technology--Horowitz (1982), Posnett and Baulkwill (1982), Shackel (1983), Terrant (1983), Turoff and Hiltz (1982). (See Bibliography) One statement in the conclusions of Posnett and Baulkwill is of particular importance for future study of the preprint.

Their topic is "Working with Non-conventional Literature," defined as the "informally published or 'grey' literature."[137] The paper was written from the user's viewpoint:[138]

> "The appreciation of the potential value of non-conventional literature is growing and there have been many improvements in its bibliographic control and processing recently, but the momentum must be maintained and increased . . . . The once-held view that non-conventional literature was necessarily only ephemeral should now be totally discarded."[139]

Further conclusions by these authors serve to support the present writer's position:

> ". . . to save future time and effort, it seems desirable to initiate more intensive research into the quantity and quality of non-conventional literature, its frequency of occurrence within various fields of knowledge and the problems of distributing it to potential users."[140]

While the preprint is not named specifically by these authors, it seems safe to conjecture that it is part of the package called "non-conventional literature." As the evidence in this paper proves, the preprint was regarded by critics of the 1960's as anything but conventional. At least one journal referred to it as an "outlaw."[141] Also, one of the respondents to this writer's inquiry indicated preprints were not collected because they were not "part of the formal, indexed primary literature."[142] A follow-up

on this cited research may be useful.

To relate this article, Posenett and Baulkwill, to the findings of the present research requires a round-about route. However, it appears worth the effort to point the way to further investigations. The article was published by the North-Holland Company in the Journal of Information Science. Through informal communication with librarians at the University of Chicago, it was learned that this same company is "currently testing the feasibility of providing a centralized machine-readable database of preprints which could be searched by researchers."[143] Although a usable response was not obtained from the publisher after several efforts, one piece of useful information was discovered that is a lead for those who investigate the preprint in the future. The appropriate name for contact is Elsevier Publishing Company, 52 Vanderbilt, New York, N. Y., 11017.

The need to re-address the issue of the interaction among all participants in the flow of information in science is emphasized in recent articles written by librarians. While the concern of the 1960's was the demise of the journal as "obsolescent,"[144] today it has become overpublication. Bertha R. Almagro, librarian at the University of Arizona Health Sciences Center, Tucson, recently wrote:

> "I am particularly concerned with the proliferation of scientific journals . . . . Libraries are highly susceptible to the demands and pressures . . . since the scientific community must have access to the most advanced scientific information."[145]

Her challenge is that referees, academia, publishers, and librarians must join together to "police the dangerous and damaging increase in professional journals."[146] This area of research also needs attention. It may well provide avenues to the preprint which, as has been shown, is primary to the content of journals.

A definite lacuna is models for the handling of preprints. While the present research has shown that many are distributed directly through scientist to scientist contact, their increasing prevalence has come to involve more librarians. Throughout the literature of the past twenty years, the only model discovered was that of the SLAC librarians. Others may be in operation in libraries of scientific communities; but, if so, they have not been communicated to the content of library or science literature. There is a need to know how others approach the problem or further means developed.

From the beginning, the primary purpose of the present paper has been to focus on the preprint in particular, but to do so, required an examination of the whole communicative process in science. Otherwise, its role would have no meaning. However, in examining formal literature, the path to information about the preprint and informal communication is studies that tend to begin, most generally, with that which is regarded as formal. For this writer and another, such a process appears to be a convolution that should be corrected. David Edge, in his defense of "soft" data over "hard" data as preeminent in exploring the communication of information in science, wrote in 1979:

> "It is my contention . . . that the tendency to characterize science in terms of formal process . . .obscures key features of scientific research. It diverts attention from 'the soft underbelly': worse, it proposes that the informal should be understood in terms of insights gained by the study of the formal. I submit that this is to reverse the priorities of explanatory logic . . . it is simply my judgment that illumination is more likely to accrue from this contrary strategy."[147]

Methods for future studies on the preprint seem implicit.

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820 Valley Lane
Lockport, Illinois 60441
October 18, 1984

Dear

As a graduate student in Library Science at Northern Illinois University, DeKalb, Illinois, I am doing an historical research of the role of the preprint in the informal information exchange among research scientists.

My letter of inquiry to is to determine

1. does your library collect and organize preprints?
2. if so, how are they obtained and organized?
3. if not, why not?

In my immediate area, I have visited the high energy physics libraries at Argonnne National Laboratories and Fermi Laboratory. Their preprint collections are extensive. Both utilize the mailing lists provided by SLAC (Stanford Linear Accelerator Center.) However, their clientele are relatively small in number, working in a highly specialized area of science.

The literature of 1960's and 1970's indicates that the preprint has been established as a significant medium of information prior to the formal publication of research. It also records the controversy and debate it has created. Less discussion appears during the 1980's. Is this an indicator of acceptance, change in attitudes, or indifference? Your opinions, as a practicing librarian, would be invaluable to my research.

If a written reply is inconvenient, I would be happy to conduct a telephone interview. I am enclosing a self-addressed envelope. A single statement indicating your choice for contact by telephone is sufficient. I will comply with your wishes following an interval of two weeks.

Thank you for your time and consideration of my request.

Sincerely yours,

Ruth Kramer

STANFORD UNIVERSITY

STANFORD LINEAR ACCELERATOR CENTER

Mail Address
Bin 82
SLAC, P.O. Box 4349
Stanford, California 94305

Jan. 29, 1985

Ruth Kramer
820 Valley Lane
Lockport, IL 60441

Dear Ms. Kramer:

I am enclosing some short articles which you may find helpful in your study of the role of the preprint in science.

As you've discovered, the preprint plays a large role in the particle physics community. In fact, I believe it is the most important form of written communication and is about even with the telephone and face-to-face discussion.

More and more preprints continue to arrive here each year; in 1970 we received 3500 preprints, in 1984, 6102. Between 70 and 80% are ultimately published somewhere.

If you produce a report or paper about your findings, I'd enjoy having a copy. Best of luck.

Sincerely,

Louise Addis
Associate Head Librarian

LXA

enclosures

SLAC LIBRARY ON-LINE

The SLAC Library computer terminals are connected to the central SLAC IBM 3081 computer, running VM/CMS and SPIRES, the Stanford Public Information REtrieval System. More than 600 such terminals are located in other areas of the laboratory.

Two public terminals in the catalog area are 'signed on' during library hours and are available to any library client who wishes to use the on-line catalogs. SLAC library users who are familiar with the computer can also use the on-line catalogs from their own terminals.

The SLAC Library completed the transition from a traditional card-catalog system, to a totally on-line system, including acquisitions and circulation, on February 1st, 1982.

At present the library maintains six major on-line databases under SPIRES (Stanford Public Information Retrieval System) as well as numerous small applications. All programming is done by library staff, who also are active in helping other groups at SLAC set up their own special purpose SPIRES databases.

The library databases include:

1. BOOKS - a complete catalog of the SLAC library book holdings integrated with our book ordering system. 13,000 records.

2. HEP - a high energy physics document database which includes all SLAC library preprint and report holdings since 1974, plus all journal articles, etc. from the DESY High Energy Physics Index (a comprehensive bibliographic tool produced at our sister laboratory in Hamburg, Germany). 110,000 records.

3. SERIALS - a complete catalog of all journal holdings plus routing and accounting information. 1100 records.

4. CONF - a file of past and future conferences of interest to the high energy physics community, including proceedings information. 1100 records.

5. INSTITUTIONS - an address and information file about the 1700 institutions in the world, which are producing theoretical or experimental high-energy physics research. 2000+ addresses.

6. HITECH - a catalog of manufacturer's addresses, phone numbers, and local distributors often needed at SLAC. Indexed by product. 4800 vendors.

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LARRY X. BESANT
Director

October 30, 1984

Ms. Ruth Kramer
820 Valley Lane
Lockport, Illinois 60441

Dear Ms. Kramer:

Your questions about "preprints" seem to me to be inconclusive. You need a definition.

However:

1) Linda Hall does not collect and organize preprints (or reprints either).

2) NA

3) Because they are not part of the formal, indexed primary literature.

Sincerely,

Larry X. Besant

LXB:ld

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A DEPARTMENT OF THE UNITED ENGINEERING TRUSTEES, INC.

October 31, 1984

Ms. Ruth Kramer
820 Valley Lane
Lockport, Illinois 60441

Dear Ms. Kramer:

Mr. Cabeen has asked me to respond to your inquiry about preprints.

In the engineering field, preprints are a very important source of information. We do collect and organize preprints of papers presented at meetings of our supporting societies (see p.6 of the enclosed folder) as well as those of many other societies whose topics are of interest to engineers. The preprints of our supporting societies are sent to us automatically. Those of other societies are requested by our Acquisitions Librarian either on a standing order basis or as a result of perusal of lists of forthcoming meetings.

Many of the preprints are indexed in Engineering Index or in Ei Meetings. The preprints themselves, if not published elsewhere, are arranged numerically and bound. We maintain indexes of the papers indicating whether or not they are published in more formal society publications such as Transactions, Conference Proceedings, Symposium Series, etc. The preprints and/or the society publications in which they appear become part of the permanent collection of the Library.

If you have any other questions, feel free to call me at (212) 705-7610.

Sincerely,

Carmela Carbone, Head
Reference Department

/cc: Encl.

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820 Valley Lane
Lockport, Il. 60441
November 29, 1984

Smithsonian Institution
Science Information-Exchange
Washington, D.C. 20560

Dear Madam/Sir:

As a graduate student in the field of library and information science at Northern Illinois University, DeKalb, Illinois, I am currently researching the role of the preprint in the informal information exchange among research scientists.

In my literature search, I found that your institution is one source of such information. Would you have any literature that would document your organization and dissemination of the preprint?

I have visited preprint libraries within my own geographical location: Fermi Laboratories, Batavia, Illinois; and Argonne Laboratories, Argonnne, Illinois. I have communicated with the John Crerar Library, Engineering Societies Library, Linda Hall Library, and Price Gilbert Memorial Library. I am aware of the SLAC Preprints in Particles and Fields.

It seems to me the preprint is a vital medium of communication among scientists for the progress of their work. It has caused controversy and debate; and, though it is prevalent in the research of communication patterns of science, it seems to be ignored as a separate entity.

Thank you for your consideration of my request. I will be looking forward to receiving any information that you may have to contribute to my research.

Sincerely yours,

Ruth Kramer

Smithsonian Institution Libraries

WASHINGTON, D.C. 20560 202-357-2240 CABLE: 89495

February 14, 1985

Ruth Kramer
820 Valley Lane
Lockport, Illinois 60441

Dear Ms. Kramer:

I have received your request for information concerning the Smithsonian's organization and dissemination of the preprint. The Smithsonian's branch library at the Astrophysical Observatory in Cambridge, Massachusetts can provide you with the most complete information on the subject of preprints. I have forwarded your letter to Joyce Rey, Branch Librarian at the observatory, for her response. You will be hearing from her soon.

I wish you the greatist success in your research. Please contact us again if we can be of further assistance.

Sincerely,

Margaret S. Child

Margaret Child,
Assistant Director
Research Services

Georgia Institute of Technology
Atlanta, Georgia 30332

Academic Affairs
Price Gilbert Memorial Library

November 12, 1984

Ms. Ruth Kramer
820 Valley Lane
Lockport, Illinois 60441

Dear Ms. Kramer:

I have been given your letter addressed to E. G. Roberts, our Director Emeritus, to reply to you. The following may be helpful or useless to you:

1) Does this library collect and organize preprints? The basic answer is no. We do however receive some preprints of meeting papers in regularly received microfiche sets.

2) If not, why not? Our user population has not requested that the Library maintain such sets.

If you would like additional information, please feel free to contact me at (404) 894-4501.

Sincerely,

Helen R. Citron

Helen R. Citron
Associate Director of Libraries

Appendix H

A Unit of the University System of Georgia

An Equal Education and Employment Opportunity Institution

THE UNIVERSITY OF CHICAGO
YERKES OBSERVATORY
WILLIAMS BAY, WISCONSIN 53191

December 3, 1984

Jane L. McKeever
Administrative Assistant for Science Libraries
John Crerar Library
5730 South Ellis Avenue
Chicago, IL 60637

Dear Jane:

I have been reading over your letter of November 8 to Ms. Kramer regarding preprints. For the record, Yerkes Observatory Library receives preprints every month and I do display and list them on a monthly basis. They are not kept for a long time; when the drawer where they are stored is full, the oldest are trashed. The Astronomy and Astrophysics Department no longer has its own numbered series of preprints; preprints are exchanged on an informal basis with a particular faculty member's own colleagues, but the Yerkes Observatory Library receives preprints on a regular basis from institutions all over the world, and I do send the list to the campus departmental office and other laboratories. Your last sentence on the first page is therefore inaccurate. So far as the preprint being a "significant medium of information exchange," I am enclosing the "yellow pages" from the Astrophysical Journal. Anyone who reads the Astrophysical Journal can request a preprint which may be of interest.

Very truly yours,

Judy Lola

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THE UNIVERSITY OF CHICAGO LIBRARY

THE JOHN CRERAR LIBRARY

5730 SOUTH ELLIS AVENUE
CHICAGO . ILLINOIS 60637

November 8, 1984

Ms. Ruth Kramer
820 Valley Lane
Lockport, Illinois 60441

Dear Ms. Kramer:

This letter is in response to your inquiry addressed to Patricia Swanson inquiring about the John Crerar Library's collections of preprints.

The John Crerar Library is now the major science library of the University of Chicago. It houses the collections in technology and the biomedical and physical sciences. A few of the physical science departments of the University also maintain small research collections in locations outside of the Crerar Library. The majority of materials for these research collections are acquired and cataloged by the centralized technical processing division of the University of Chicago Library system.

The Library of the Research Institutes is one of the research collections described above. It serves the scientists of the James Franck Institute and the Enrico Fermi Institute. These institutes issue preprints which are sent to other researchers in exchange for their series of preprints. These exchange lists are maintained by each research group, and the library does not become involved in acquisition decisions.

The preprints received by the Research Institutes are forwarded to to Institutes' library. Each preprint is given an accession number which is then used as the means of retrieving it. The first author is given a catalog entry. The only other information on this catalog card is the accession number. Cross-references appear in the catalog from additional authors to the first.

The preprints are displayed for one week upon receipt, and are then located by accession number on open shelving. The preprints are thus available to be checked out of the library. They are retained for one year and then discarded. This retention policy is based on research which shows that if the article is to be published, it will be during this one year period.

The Research Institutes Library receives approximately 300 preprints each month. Based on the retention policy, there are 3,000 to 4,000 preprints in the collection at any one time. Preprints are not acquired by any other University of Chicago libraries.

The librarian of the Research Institutes is Scott Lee. In response to your question concerning controversies about the role of the preprint, Lee states that the preprint's acceptance by scientists as a significant medium of information exchange is unquestioned. The preprint is one of the first ways, outside of personal communications, to learn of progress on research problems.

In view of your research interests, Lee suggested that you might want to contact the North Holland Physics Publishing Company. They are currently testing the feasibility of providing a centralized machine-readable database of preprints which could be searched by researchers. Individual papers could be printed on-demand. The individual at North Holland who has more information is Mr. R. T. De Ruiter, Senior Editor.

I trust that this letter is responsive to your inquiry. If you have further questions, please contact me at (312)962-7720 or Scott Lee at (312)962-7351.

Sincerely,

Jane L. McKeever

Jane L. McKeever
Administrative Assistant
for Science Libraries

cc: Scott Lee

THE UNIVERSITY OF CHICAGO LIBRARY
THE JOHN CRERAR LIBRARY
5730 SOUTH ELLIS AVENUE
CHICAGO • ILLINOIS 60637

December 16, 1984

Ms. Ruth Kramer
820 Valley Lane
Lockport, Illinois 60441

Dear Ms. Kramer:

I had shared a copy of my previous letter to you with the University of Chicago science librarians. Judy Lola, the librarian at the Yerkes Observatory in Williams Bay, Wisconsin, responded by providing some information about that library's collection of preprints. Because I know you would find her letter informative, I am enclosing a copy.

Sincerely,

Jane L. McKeever

Jane L. McKeever
Administrative Assistant
for Science Libraries

Smithsonian Institution Libraries

WASHINGTON, D.C. 20560 202-357-2240 CABLE: 89495

Astrophysical Observatory
60 Garden Street
Cambridge, MA 02138

Ms. Ruth Kramer
820 Valley Lane
Lockport, IL 60441

March 26, 1985

Dear Ms. Kramer:

Thank you for your letter of March 11, which has just reached me -- I did not receive anything from Dr. Child, so I hope I'm not too late to be of help to you.

Preprints have become a vital resource in libraries involved in state-of-the-art science. I can vouch for this being the case in physics, astrophysics, and the space sciences in general, and would assume this also to be the case in biological sciences, and probably medicine, but do not know this from personal experience. This phenomenon appears to occur in subject areas in which most of the up-to-date information appears in journals and conference proceedings, and the preprint route bypasses the frustration and delay involved in waiting for the often-delayed official publication.

One very good indication of their value to scientists, if not a very scientific assessment, is apparent in the frequency in which such material disappears from the display shelves in this library!

Unfortunately, I cannot help by directing you to a definitive article on the subject -- maybe you should publish your paper in the library literature when it is completed! In this library, we have a system of recording a shortened version of the title, author and source, with reference number, if any, on the VAX, using a simple word-processing technique. This can then be read and searched by any interested scientist using his/her own terminal by calling up the file on an editor. We also publish our own Center for Astrophysics (Harvard/Smithsonian) series of preprints -- these are distributed to interested members of the astronomical community, and quarterly lists are printed and circulated to anyone asking for them. They can then make their own selection. Some librarians list and circulate monthly lists. In fact, one tends to be guided to a large extent by the demands of the clientele.

There are many caveats involved in handling preprints. How many staff members do you have? The library at the Stanford Linear Accelerator Laboratory keeps

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track of everything, as I recall, and culls preprints as they are published. Here one must watch for changes in title, order of authors, journal of publication (the original one to which the article was submitted may have turned it down). In fact, sometimes you may miss them because they are not even recognizable. (We just throw them out for lack of storage space after a year or so!) Also, some of them never reach print at all, having been left out of conference proceedings for lack of space, content, etc.

I'm afraid I haven't helped much -- except to list the problems, without offering solutions. I think you should establish their vital importance in certain fields, and if you come up with a good way of handling them, please let me know! As an aside, I think I should mention that Dr. Child sent the letter I haven't seen to me because I am the only librarian working for the Smithsonian Libraries who has ever raised this point with them, asking for guidance. My colleagues, who work in natural history, botany, art, and general museum situations, had no interest or concern with the problem, which never, apparently, comes up in their libraries. I was advised to do with them as I thought best!

I do hope this has been of some interest, and I wish you good luck with your paper for your M.A.!

Sincerely yours,

Joyce M. Rey

Joyce M. Rey
Librarian